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Whither the Unemployment Rate?

Brian Motley*

This article develops a model of short-run changes in the unemployment rate and uses it to make forecasts of the rate in 1985. The model is based on Okun's Law which relates changes in unemployment to the growth rate of aggregate demand. It differs from earlier models, including Okun's own work, because it estimates explicitly the growth rate of demand that is required to offset increases in labor force participation and labor productivity rather than assuming that growth rate to be constant. The unemployment rate changes in response to the differential between the actual growth of GNP and this "required" growth rate.

Between December 1982 and June 1984, the unemployment rate in the U.S. declined from 10.7 percent to 7.2 percent of the civilian labor force. Over this same period, real GNP grew at a rapid 6.8 percent annual rate. Since last June, however, real GNP growth has slowed and no further progress has been made in lowering the unemployment rate. Moreover, most economic forecasters do not expect real growth to pick up in 1985, with most estimates for the year in the 3–4 percent range.

An important issue facing economic policymakers is whether real growth in this range would be sufficient to bring about significant further reductions in the unemployment rate. Many economists argue that it probably would not be, but that any attempt to pursue more rapid real growth would risk jeopardizing the hard-won gains in bringing down inflation in recent years. Others agree that faster real growth is required to reduce unemployment to any significant extent, but argue that the risk of faster inflation is worth running, in view of an unemployment rate that remains high by historical standards. In the twenty-five years before 1975, unemployment exceeded six percent of the civilian labor force in only two years, 1958 and 1961, but in the last ten years it has been *below* six percent only once.

One piece of information that is required to make a judgment on this issue is an estimate of the response of the unemployment rate to changes in the growth rate of real GNP. To this end, this paper develops a model that provides short-term predictions of the unemployment rate given expectations of the growth rate of real GNP. This model extends the work reported in a recent *Economic Review* article[1] that developed long-term projections of the unemployment rate. Like that earlier long-run model, the analysis in this paper is based on the observed relation between changes in the unemployment rate and the rate of growth of real GNP, also known as *Okun's Law*.

To bring down the unemployment rate, the real demand for the economy's output of goods and services must increase. Indeed, a certain minimum rate of economic growth is required simply to prevent the unemployment rate from rising. For example, increases in the total population and in the proportion of the population that wants to work mean that to prevent an increase in unemployment, the demand for output must grow enough to create jobs for these new entrants to the labor force. Similarly, the productivity of labor (that is, output per employed worker) generally rises through time, so

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that unless the demand for goods and services increases at least as rapidly as output per worker, the demand for labor will decline and unemployment will mount.

In this article, the rate of growth in the demand for real GNP that is needed to offset changes in the labor force and productivity exactly—and thus to hold the unemployment rate constant—will be termed the *required GNP growth rate.*[2] To predict the impact on unemployment of a particular rate of growth of real GNP, an estimate of this required growth rate is needed. This article develops a set of equations that explain changes in labor productivity and in the size of the labor force, and uses these equations to derive estimates of the required GNP growth rate.

Over the business cycle, the actual growth rate of real GNP diverges from the required growth rate and, as a result, unemployment rises and falls. In the recovery phase of the cycle, for example, output increases more rapidly than the required rate and the unemployment rate consequently declines. During the recession phase, the reverse occurs. Okun's Law (See Box 1) summarizes the relationship between changes in the unemployment rate and cyclical variations in the rate of GNP growth relative to the required rate. It provides a "rule of thumb" for estimating how much the unemployment rate will change in response to a given change in real GNP. For example, Okun's own estimate of this rule of thumb was that a *three* percentage point increase in the growth rate of real GNP above the required rate would be associated with a *one* percentage point decline in the unemployment rate.

However, most previous estimates of this relationship, including Okun's own estimates, have assumed that the required rate of GNP growth remained constant over the sample period. If this assumption were not correct, the estimates of the relation between GNP growth and changes in the unemployment rate might be biased. The Okun's Law equation developed in this paper avoids this assumption by using the estimates of the required rate derived from the analysis of the determinants of labor force participation and labor productivity.

The Model

The accounting relation between real GNP and total employment may be represented in the following identity:

$$Y/Pop \equiv (Y/E) \times (E/L) \times (L/Pop) \qquad (1)$$

where

Y = Real GNP
E = Civilian employment
L = Civilian labor force
Pop = Adult population[3]

This identity shows that real output per capita, Y/Pop, may be decomposed into the product of (i) output per employed worker, Y/E,[4] (ii) employment as a proportion of the labor force, E/L, and (iii) the labor force as a proportion of the population, L/Pop. Using lower case letters to represent the ratios in Equation 1, this identity also may be written in terms of growth rates:

$$\text{dln } y \equiv \text{dln } q + \text{dln } e + \text{dln } p \qquad (2)$$

where

y = real GNP per capita, Y/Pop
q = labor productivity, or real GNP per employed worker, Y/E
e = the employment ratio, or the proportion of the labor force that is employed, E/L
p = the participation rate, or the proportion of the population that is in the labor force, L/Pop, and

dln represents the change in the logarithm, and thus the growth rate, of each variable.

Since our principal interest is in the growth of employment, and hence of unemployment, it is useful to rearrange this equation and write it as:

$$\text{dln } e \equiv \text{dln } y - (\text{dln } q + \text{dln } p) \qquad (3)$$

If the growth rates of labor productivity (dln q) and labor force participation (dln p) were to depend only on technological, demographic and other non-economic factors that remained constant over time, the forecasting of the employment ratio would be relatively straightforward. Suppose, for example, that la-

Box 1
Okun's Law

When first introduced in 1962, Okun's Law was designed to estimate *potential output.** Okun's objective was to compute the level of real GNP that would be produced if the economy were operating at full employment, and thus to estimate the "costs"—in terms of lost output—incurred when it was at less than full employment. Okun hypothesized that the "gap" between actual and potential output was proportional to the difference between the actual unemployment rate and the rate that would be observed at "full employment." Thus,

$$u - u^F = b\left[\frac{P - A}{A}\right] \qquad \text{(B1)}$$

where u and u^F represent the actual and "full employment" values of the unemployment rate and P and A represent potential and actual values of real GNP.** Okun assumed that full employment corresponded to a measured unemployment rate of four percent and thus that potential output corresponded to the level of GNP that would be reached at a four percent unemployment rate.

Using a variety of techniques, Okun estimated that the value of b in this expression was close to one-third, giving rise to his rule of thumb that "each percentage point in the unemployment rate above 4 percent has been associated with about a 3 percent decrement in real GNP."

In discussions of short-run policy, this rule frequently is expressed in terms of the growth rate of real GNP rather than of the gap between actual and potential output. In this form, the rule states that a 3 percentage point reduction in the annual *growth rate* of real GNP will be associated with a one percentage point increase (per year) in the unemployment rate. It is frequently more informative to the policymaker to know the likely impact on the unemployment rate of a given *change* in real GNP growth than to know the costs in terms of lost potential output of a given unemployment rate. Moreover, there is less unanimity among economists today on what measured rate of unemployment corresponds to "full employment", and hence what "potential GNP" is, than there was when Okun wrote his article. This makes it more difficult to estimate the Law in the form of Equation B1.

Although, in this paper, the Law has been stated and estimated in its "growth rate" form, it is important to recognize that the "growth rate" and "gap" versions of the Law are simply alternative ways of stating the same basic relationship.*** Clearly, if the potential (or required) growth rate of the economy does not change, a three percentage point increase in the annual growth rate of actual GNP will reduce the "gap" between potential and actual GNP by three percentage points. In either formulation, this will lower the unemployment rate by one percentage point.

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*Arthur M. Okun, "Potential GNP: its Measurement and Significance," *Proceedings of the Business and Economic Statistics Section of the American Statistical Association,* 1962.

**Since u is approximately equal to $-\ln e$ and $(P - A)/A$ is approximately equal to $-\ln(A/P)$, this hypothesis also may be written as

$$\ln e - \ln e^F = b(\ln A - \ln P).$$

By assuming that potential GNP grows at an annual rate r, this expression may be written as

$$\ln e = (\ln e^F - b \ln P_0) + b \ln A - b\, rT,$$

where T represents time and P_0 is the level of potential GNP when T is zero.

In his empirical estimates, Okun used this version of this relation as well as the one represented by Equation B1 with similar results.

***Note that the formulation used in the body of this paper may be obtained from the expression in the preceding footnote by differentiating it with respect to time.

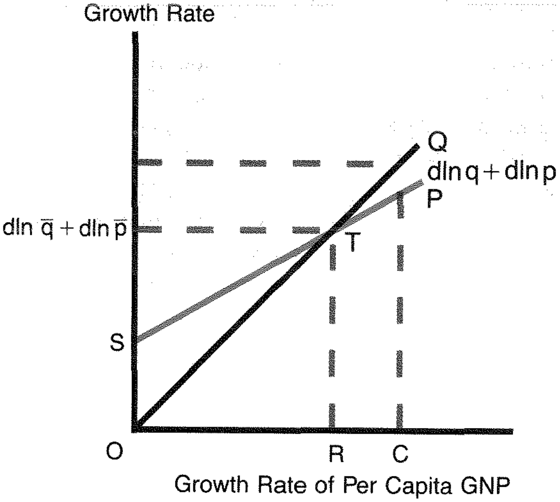
bor productivity were known to rise at a constant *two* percent a year and the available labor force at *one* percent. In this case, the required GNP growth rate would be *three* percent since if real aggregate demand were to increase at that rate, the growth in the demand for labor would exactly match the growth in the supply, and the proportions of the work force that were employed and unemployed would remain constant. In terms of Equation 3, if real GNP were to grow at three percent a year, dln e would be zero because dln y would be exactly equal to the sum of dln q and dln p.

If real GNP were to increase by more than three percent, the proportion of the labor force employed would rise. In particular, Equation 3 shows that, in the special case in which the growth rates of participation (dln p) and of productivity (dln q) are constant, an increase in the annual GNP growth rate of, for example, *one* percentage point (from three percent to four percent), would cause the employment ratio to grow at an annual rate of *one* percent and hence would cause the unemployment rate to decline by *one* percentage point per year.[5]

Thus, if the growth rates of productivity and the labor force were constant, the required GNP growth rate also would be constant and each *one* percentage point increase in the actual GNP growth rate above the required rate would produce a *one* percentage point decline in the unemployment rate.

In fact, the growth rates of productivity and the labor force are *not* constant. The demographic, technological and other non-economic factors that affect labor force participation and productivity growth vary over time, and these variations lead to changes in the required GNP growth rate. In addition, participation and productivity also respond to changes in the growth rate of real GNP over the business cycle. More rapid GNP growth during a business cycle expansion, for example, tends to be associated with faster growth both in output per worker (partly because hours of work increase) and in labor force participation. This means that a given increase in real GNP growth leads to a smaller increase in the employment ratio than

Figure 1
Determining the Required Growth Rate



if the growth rates of productivity and participation were unchanged. In terms of Equation 3, since the rise in dln y associated with a cyclical upswing typically is accompanied by increases in both dln q and dln p, the increase in dln e is correspondingly smaller.

Figures 1 and 2 illustrate these arguments graphically. In these figures, the horizontal axis represents the growth rate of per capita GNP. The 45-degree ray OTQ identifies points at which the growth rates measured on the vertical and horizontal axes are equal. Figure 1 illustrates the determination of the required GNP growth rate and shows how changes in the growth rate of GNP over the business cycle lead to increases and decreases in the employment rate, while Figure 2 illustrates the effect of demographic, technological and other non-cyclical factors on the required GNP growth rate.

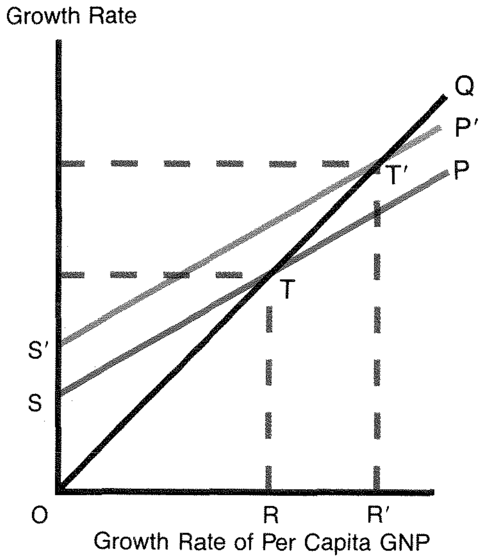
In Figure 1, the curve STP, labeled dln q + dln p, represents the combined growth rate of productivity and participation. This curve slopes upward to illustrate the tendency for the growth of both productivity and participation to increase and decrease as the growth rate of real GNP rises and falls over the business cycle.

For simplicity, STP is represented as a straight line. The accounting identity in Equation 3 implies that the vertical distance of the curve STP above or below the ray OTQ represents the rate of change of the employment ratio. Hence, the intersection of the curve STP with the ray OTQ at the point T identifies the growth rate of per capita real GNP at which the employment ratio remains unchanged. At this intersection, the combined growth rate of productivity and participation is exactly equal to the growth rate of per capita GNP. This growth rate of productivity and participation is labeled $\mathrm{dln}\,\bar{q} + \mathrm{dln}\,\bar{p}$.

The GNP growth rate which holds the employment ratio constant is the "required growth-rate." In Figure 1 this growth rate is OR. If real aggregate demand per capita grows at the required rate, the combined growth rate of productivity and participation, RT, is exactly equal to the growth rate of per capita GNP, OR. Hence, the demand for labor rises at the same rate as the supply, and the employment ratio remains unchanged.

Figure 2

An Increase in the Required Growth Rate



In a cyclical upswing, when the actual growth rate of real GNP rises above the required growth rate, OR, the combined growth rate of productivity and participation also increases *but by a lesser amount.* Hence, the employment ratio increases. For example, if GNP per capita grows at rate OC, productivity and participation together grow at rate CP. Although this growth rate is above the required GNP growth rate, OR, it is less than the actual GNP growth rate, CQ. Hence, the employment ratio increases at rate PQ. Conversely, when real GNP growth is less than OR, the growth rate of productivity and participation is greater than that of GNP so that the employment ratio declines.

When the growth rates of participation or productivity increase or decrease for reasons that are *not* related to the business cycle, the required GNP growth rate will change. An increase in the trend rate of growth of labor force participation, for example, adds to the supply of labor, which means that real aggregate demand must increase more rapidly if there is to be no increase in unemployment. Similarly, faster trend growth in labor productivity reduces the demand for labor; if unemployment is to remain unchanged, this must be offset by faster output growth. Thus, in both of these instances, the required GNP growth rate rises. In Figure 2, such changes are represented by an upward shift of the curve STP to S′T′P′. As a result, the intersection point with OTQ is shifted from T to T′ and the required growth rate increases from OR to OR′. The empirical section below attempts to quantify such shifts and to derive estimates of how the required growth rate has changed over time.

The preceding argument also may be stated in algebraic terms. The hypothesis that a cyclical increase (decrease) in the growth rate of per capita GNP leads to a lesser increase (decrease) in the combined growth rate of productivity and participation may be written as

$$\mathrm{dln}\,q + \mathrm{dln}\,p = \alpha + \beta\,\mathrm{dln}\,y \qquad (4)$$
$$\text{where } 0 < \beta < 1$$

This equation represents the curve STP in Figure 1. The intercept term, α, represents the effect of technological, demographic or other noncyclical factors that affect the growth rates of productivity and participation. The slope coefficient, β, represents the response of productivity and participation to variations in the growth rate of per capita GNP over the business cycle. Substituting this equation into Equation 3 and re-arranging terms yields

$$\text{dln } e = -\alpha + (1 - \beta) \text{ dln } y \qquad (5)$$

As illustrated in Figure 1, when per capita GNP is growing at the required rate, dln y^R, the employment ratio is constant and the growth rate of per capita GNP is equal to the combined growth rate of productivity and participation. Thus,

$$\text{dln } y^R = \text{dln } \bar{q} + \text{dln } \bar{p} = \alpha + \beta \text{ dln } y^R \qquad (6)$$

where dln $\bar{q}$ and dln $\bar{p}$ represent the growth rates of productivity and participation when per capita GNP is growing at the required rate. Equation 6 represents the growth rate of per capita GNP at the intersection point T in Figure 1. As was illustrated in Figure 2, a change in the value of the intercept term, α, which represents the effect of non-cyclical variables on the growth of productivity and participation, alters the required growth rate.

When Equation 6 is solved for α and the resulting expression is substituted into Equation 5 it yields:

$$\text{dln } e = (1-\beta)(\text{dln } y - \text{dln } y^R) \qquad (7)$$

This equation, which is a form of Okun's Law, shows that the growth rate of the employment ratio depends on the *differential* between the actual and required growth rates of real GNP. However, most estimates of this equation, including Okun's own, have assumed that the required growth rate was constant and hence that changes in the employment ratio depend only on the *actual* GNP growth rate.

More recent research[6] suggests that this assumption that the required growth rate does not change over time may not be an accurate one and hence that estimates of Equation 7 made under that assumption may be biased. This suggests that an alternative and preferable procedure is to construct a statistical series for the required growth rate, dln y^R, and to use it to estimate Equation 7. This is the procedure employed in the following empirical section.

Empirical Results

To estimate Equation 7, a statistical series for the required GNP growth rate must be constructed. The previous section showed that this growth rate varies in response to changes in the demographic, technological and other non-cyclical factors that influence productivity and labor force participation. This argument suggests that a statistical series for the required growth rate, dln y^R, may be constructed in a series of steps. First, separate equations are estimated to explain labor productivity and labor force participation in terms of both cyclical and non-cyclical variables. Second, these equations are simulated over the sample period holding the cyclical variables constant. The growth rates of these simulated values are interpreted as estimates of dln $\bar{q}$ and dln $\bar{p}$—the growth rates of productivity and participation that would arise if there were no cyclical variations in the economy and hence a situation in which the unemployment rate remained constant. On this interpretation, the sum of these simulated growth rates represents dln y^R, the required GNP growth rate.

Separate equations were estimated for the female and male participation rates and for labor productivity. Earlier research[7] suggested that both participation and productivity may be adequately modeled using a cyclical variable, a few demographic variables and a series of trend variables. In the present context, it was natural to follow this previous research and choose the employment ratio as the cyclical variable since the required growth rate is defined as the rate that holds that ratio constant.[8] Full details of the estimated equations are shown in the table in Box 2. The estimation period was from the first quarter of 1953 to the last quarter of 1982.

Each estimated equation was simulated dynamically over the sample period, holding the employment ratio constant at its 1953(Q1) level[9]. This procedure computes how productivity and participation would have changed

Box 2
Estimating the Required GNP Growth Rate

The required GNP growth rate is the rate at which real aggregate demand must grow in order that the employment ratio remains constant. It is the growth rate which just suffices to provide jobs for new entrants to the labor force and to offset increases in output per worker. The principal difficulty involved in estimating this growth rate is that the rates at which labor force participation and labor productivity increase are themselves influenced by changes in the rate of output growth over the business cycle. This was illustrated in Figure 1.

The first stage in the estimation process is to estimate equations to explain output per employed worker and the female and male participation rates in terms of both cyclical and noncyclical variables. The variables used in these equations were chosen on the basis of an examination of earlier research (See Footnote 7). In this research, the effect of the business cycle generally is represented by some indicator of labor market tightness. In this paper, both the level and the quarterly change in the employment ratio were included as regressors to represent cyclical influences.

Labor productivity and labor force participation exhibit significant time trends. It is widely argued that the trend of participation changed during the sixties and that of productivity slowed in 1969 and perhaps again in 1974. Hence, an initial version of the equations included a series of dummy variables representing linear trends that shifted at various dates. A second version sought to capture these varying trends by a fourth-order polynomial in time. This second version provided a closer fit to the sample data and also yielded coefficients on the demographic variables that were statistically significant and of the correct sign. This is the version reported in the table below.

The equation explaining output per worker includes a special dummy variable to capture a bias in the measurement of labor productivity resulting from the imposition and subsequent removal of price controls in 1971–1974.* Since such controls can never be perfectly effective and probably became less effective as time passed, it is likely that "announced" prices increasingly understated "true" prices during the control period. Since real GNP is measured by deflating nominal GNP by a price index that represented announced prices, this would cause the growth of output per worker to be overestimated during the control period and correspondingly under-estimated while the controls were being dismantled. The dummy variable, DPC, which seeks to capture this effect takes the value 1 from 1971(Q3) to 1973(Q1), −1 from 1973(Q2) to 1974(Q4), and 0 at all other dates. The above argument implies that the coefficient on this variable is expected to be positive.

Overall male participation in the labor force has been declining in the last thirty years. However, to a significant extent, this decline reflects the falling participation of older males which probably represents an exogenous demographic trend. The decrease in the participation of prime-age males has been much smaller. To capture this demographic change, the equation explaining the male participation rate includes the participation rate of males over age 55, PARTM55, as an independent regressor.

For similar demographic reasons, the equation explaining female participation includes a variable, INFANT, representing the number of young children relative to the female population. This variable began to decline at about the same time as the upward trend of female participation accelerated in the 1960s. Although a more complete analysis of the determinants of female labor force participation would treat decisions on child-rearing and participation as jointly determined, the number of children is effectively pre-determined in a single quarter. Hence, this variable also is regarded as an exogenous demographic factor.

Hence, the equations estimated were as follows:

Output Per Worker

$$\ln q_T = g_0 + g_1T + g_2T^2 + g_3T^3 + g_4T^4 + g_5DPC_T + g_6\ln e_{T-1} + g_7 d\ln e_T + g_8\ln q_{T-1}$$

Female Participation

$$\ln p_T^F = f_0 + f_1T + f_2T^2 + f_3T^3 + f_4T^4 + f_5INFANT_T + f_6\ln e_{T-1} + f_7 d\ln e_T + f_8\ln p_{T-1}^f$$

Male Participation

$$\ln p_T^M = m_0 + m_1T + m_2T^2 + m_3T^3 + m_4T^4 + m_5PARTM55_T + m_6\ln e_{T-1} + m_7 d\ln e_T + m_8\ln p_{T-1}^m$$

The table below reports the results of estimating these equations.

In constructing the series for the required GNP growth rate, each estimated equation was simulated over the sample period holding $\ln e_{T-1}$ equal to its value in the second quarter of 1953 and $d\ln e_T$ equal to zero. The simulation was dynamic in the sense that in each quarter the value of the lagged dependent variable was set equal to its *simulated* value in the preceding quarter. The simulated male and female participation rates were combined to form the total participation rate. The sum of the growth rates of these simulated values of overall participation and of productivity represents the estimated growth rate of per capita GNP that would hold the employment rate constant at its 1953(Q1) level. This growth rate, $d\ln \hat{y}_T^R$, was used in the estimates of Equation 7.

*For a detailed discussion of the impact of price controls on measured productivity growth, see Charles S. Morris, "The Productivity 'Slowdown': A Sectoral Analysis," *Economic Review,* Federal Reserve Bank of Kansas City, April 1984.

Female and Male Participation and Labor Productivity

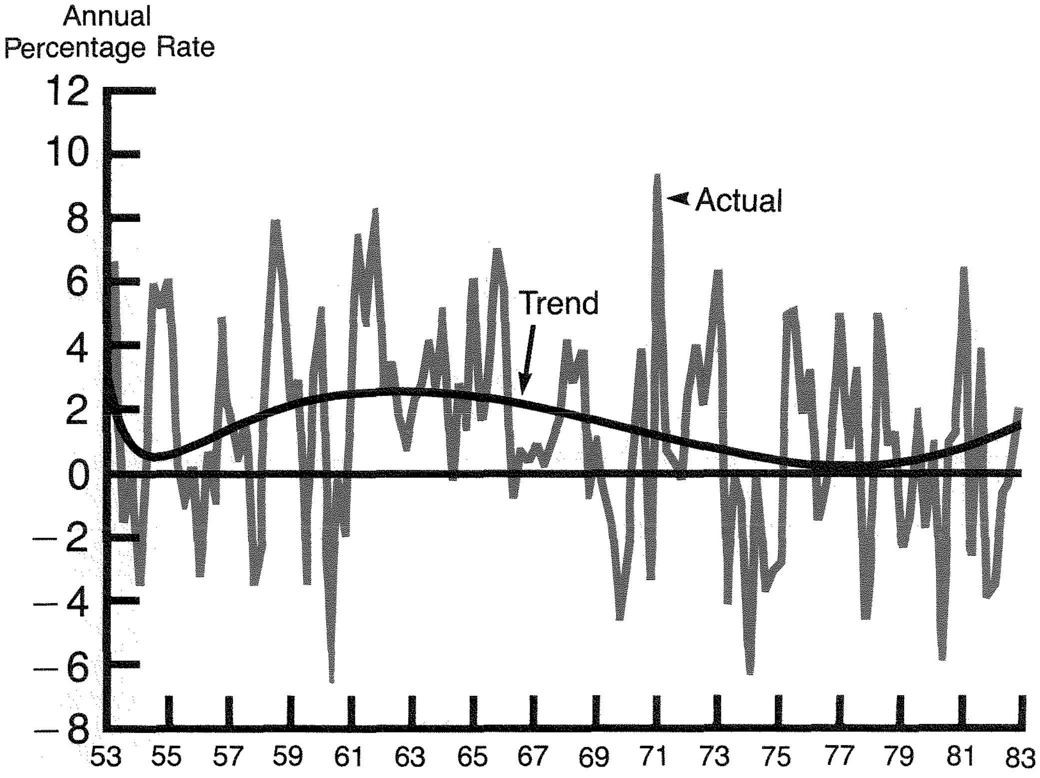
Independent Variables	Female Labor Force Participation Rate	Male Labor Force Participation Rate	Real GNP Per Employed Worker
Constant	−0.636	−0.428	2.573
	(6.26)	(2.434)	(4.348)
$\ln e_{T-1}$	0.236	0.073	−0.019
	(3.955)	(3.906)	(0.243)
$d\ln e_T$	−0.130	−0.060	1.058
	(1.01)	(1.105)	(6.445)
Price Control Dummy (DPC)			0.00328
			(1.880)
INFANT	−0.187		
	(3.695)		
LPARTM55		0.0558	
		(2.134)	
TIME	4.729E−3	3.620E−4	−6.984E−4
	(6.250)	(1.543)	(1.766)
TIME^2	−1.107E−4	−3.102E−5	8.048E−5
	(5.834)	(3.676)	(4.508)
TIME^3	9.318E−7	4.104E−7	−1.033E−6
	(4.952)	(3.898)	(4.650)
TIME^4	−2.311E−9	−1.606E−9	3.944E−9
	(2.829)	(3.921)	(4.582)
Lagged Dependent Variable	0.612	0.539	0.722
	(10.427)	(6.922)	(11.304)
SEE	0.00615	0.00822	0.00627
DW	2.06	1.73	1.91

over the sample period if the employment ratio had remained constant. The simulated values of the male and female participation rates were combined into an overall participation rate. Finally, the growth rates of simulated total participation and labor productivity were summed to yield a series of the required growth rate of per capita real GNP that would hold the employment ratio constant at its 1953(Q1) level.

Charts 1–3 show the actual and simulated values of productivity and of male and female participation. Although most of the variation in all three variables represents the business cycle, it is clear that even when the effects of the cycle are removed, a significant amount of variation remains. Chart 4 shows the actual and required growth rates of per capita real GNP. Toward the end of the sample period, the required per capita GNP growth rate was approximately two percent, but it was significantly lower through most of the 1970s. This constructed series of the required GNP growth rate was used to estimate an empirical version of Equation 7.

Most previous estimates of Okun's Law have found that the employment ratio responds to changes in the GNP growth rate with a lag. The theoretical model represented in Equation 7 implies that this lagged response should refer to the *differential* between the actual and required growth rates, suggesting that the empirical form of Equation 7 should include current and lagged values of both the actual and the required growth rates of per capita GNP. In

Chart 1
Growth Rate of Productivity
Actual vs. Trend



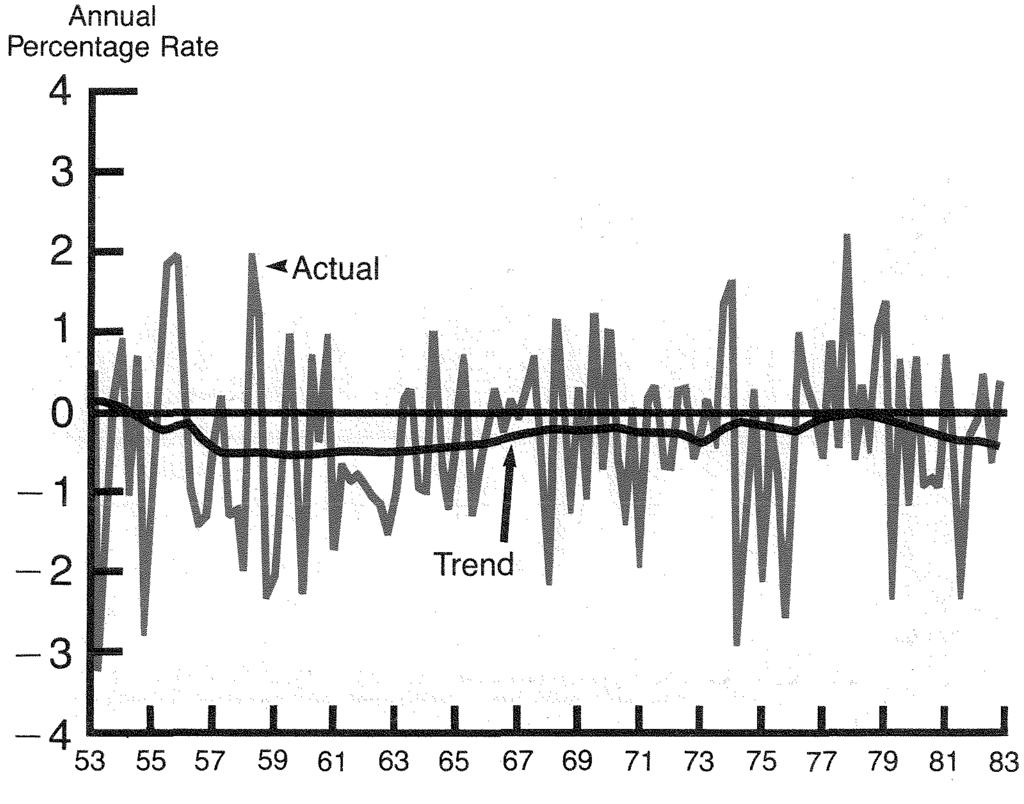
practice, because the required growth rate is a smooth series, its current value is a good proxy for its lagged values.[10] Hence, the estimated equation was:

$$\operatorname{dln} e_t = a + b_0 \operatorname{dln} y_t + b_1 \operatorname{dln} y_{t-1} + b_2 \operatorname{dln} y_{t-2} - c \operatorname{dln} \hat{y}^R_t \quad (8)$$

where $\operatorname{dln} y^R_t$ represents the constructed series of the required GNP growth rate. The proposition embodied in Equation 7 that growth in the employment ratio is proportional to the differential between the actual and required GNP growth rates implies that the intercept term in Equation 8 should be zero and that the sum of the coefficients on the current and lagged growth rates of per capita GNP should be equal to the coefficient on the required growth rate, that is, $b_0 + b_1 + b_2 = c$.

The results of estimating this equation, and testing these hypotheses, are set out in Table 1. In that Table, Equation A shows the estimated coefficients of Equation 8 with no restrictions. All coefficients carry the signs predicted by the theory. Although the sum of the estimated coefficients on the current and lagged values of the GNP growth rate is not exactly equal to the coefficient on the required rate, the hypothesis that they are equal cannot be rejected at conventional significance levels. In addition, Equation A confirms the prediction that the intercept term should be zero; the estimated intercept is small and not statistically significant. When the intercept is eliminated in Equation B, the sum of the coefficients on $\operatorname{dln} y_t$ is much closer to that on $\operatorname{dln} \hat{y}^R_t$. Finally, constraining these values to be equal, as in

Chart 2
Growth Rate of Male Participation Actual vs. Trend



Equation C, has no noticeable effect on the estimated coefficients.

For comparison, Equation D reports the result of restoring the intercept but excluding the variable dln $\hat{y}_t^R$. This equation corresponds to a specification in which the required growth rate of real GNP is constant and equal to $-a/(b_0 + b_1 + b_2)$. As pointed out above, earlier research suggested that this specification is not supported by post-war U.S. data[11]. This finding is confirmed by its standard error, which is slightly larger than those for the earlier equations.

Equation C is the empirical counterpart of Equation 7 and incorporates the coefficient restrictions suggested by the theory. It implies that, in order to increase the annual growth rate of the employment ratio by one percent (that is, to lower the unemployment rate by one percentage point per year), actual per capita GNP must increase at a rate two percentage points above the required rate. This compares with Okun's estimate of three percentage points. Several other studies made since Okun's initial work, which used data from the 1950s, also have suggested that the unemployment rate has become more responsive to changes in the GNP growth rate.[12]

Chart 5 shows the quarter-to-quarter changes in the unemployment rate and compares them to those derived from the fitted values of Equation C in Table 1[13]. Given the substantial volatility of the unemployment rate, the fit of the equation appears to be quite good.

Chart 3
Growth Rate of Female Participation Actual vs. Trend

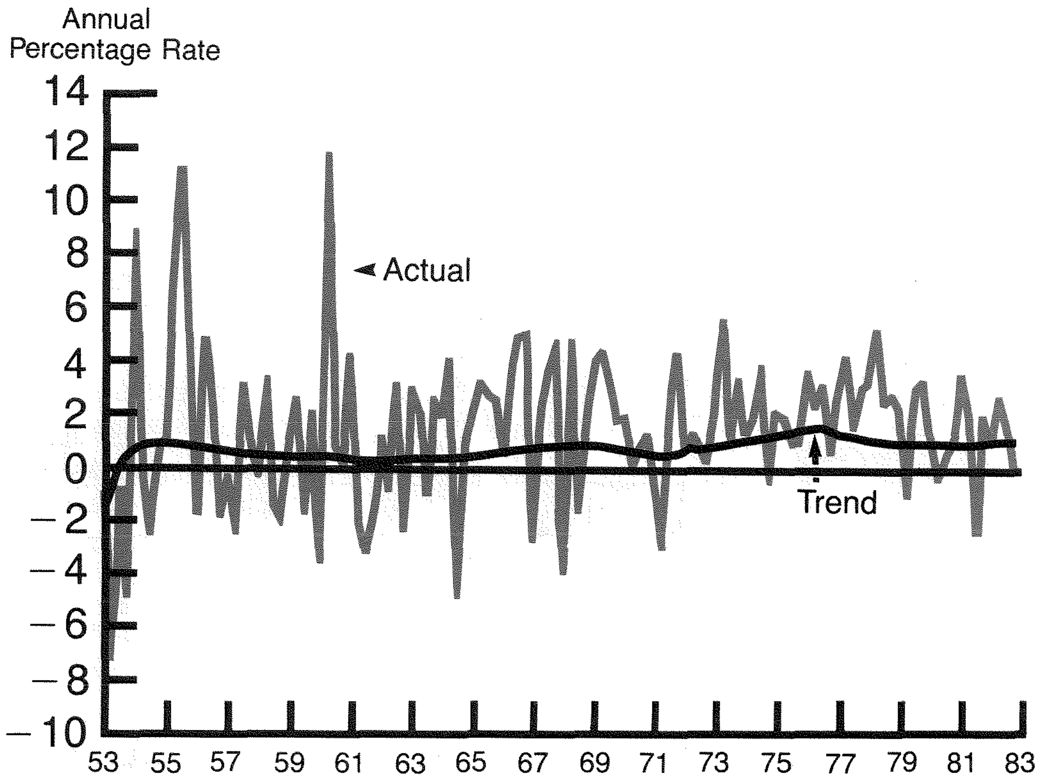


TABLE 1
Estimates of Okun's Law

	Equations A	B	C	D
Constant	−0.0010			−0.0023
	(1.49)			(10.25)
$d\ln y_t$	0.253	0.253	0.254	0.250
	(11.94)	(11.90)	(12.01)	(11.69)
$d\ln y_{t-1}$	0.179	0.181	0.181	0.176
	(7.98)	(8.01)	(8.04)	(7.76)
$d\ln y_{t-2}$	0.066	0.067	0.067	0.062
	(3.13)	(3.16)	(3.19)	(2.91)
Sum	0.498	0.501	0.503	0.487
	(18.71)	(18.78)	(18.91)	(18.44)
$d\ln\hat{y}_t^R$	−0.306	−0.533	−0.503	
	(1.92)	(10.38)	(18.91)	
SEE	0.00225	0.00226	0.00225	0.00227
DW	1.65	1.61	1.62	1.60

TABLE 2
Unemployment Forecasts 1983–84

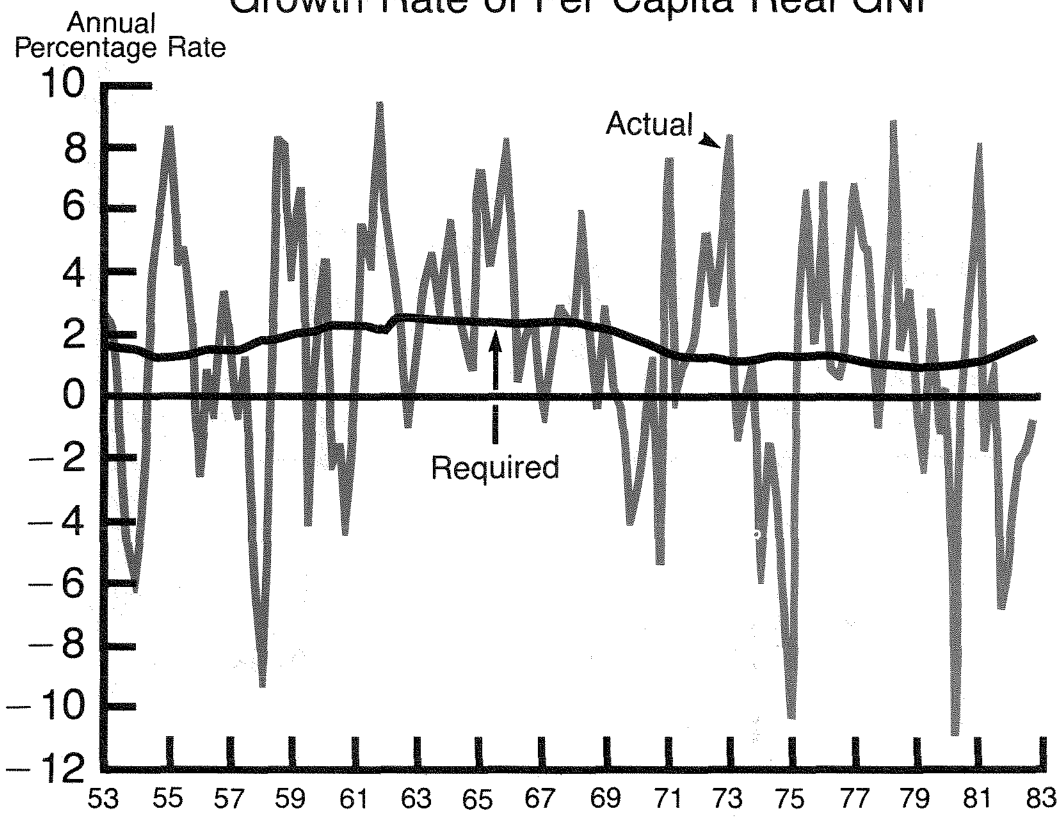
	Change in Unemployment Rate (Percentage Points) Predicted	Actual	Error
1983 Q1	+0.16	−0.23	+0.39
Q2	−0.30	−0.24	−0.06
Q3	−0.43	−0.80	−0.37
Q4	−0.37	−0.86	−0.49
1984 Q1	−0.48	−0.60	−0.12
Q2	−0.49	−0.37	+0.12
Q3	−0.13	−0.09	−0.04
Q4	+0.01	−0.22	−0.23
1982 Q4/1983 Q4	−0.95	−2.13	−1.18
1983 Q4/1984 Q4	−1.09	−1.27	−0.18

Predictions and Policy Implications

To test its predictive power, the model was used to forecast the unemployment rate over the period from 1984(Q1) to 1984(Q4). The forecast was made in two stages. In the first stage, the equations estimated in Box 2 were simulated over the forecast period holding the employment ratio constant at its 1953(Q1) level, and the resulting projections of labor productivity and participation were combined to yield quarterly estimates of the required per capita GNP growth rate. Over the eight-quarter forecast period, this required growth rate was estimated to increase modestly and to average slightly above two percent. In the second stage of the forecasting procedure, these projections of the required rate were entered into Equation C in Table 1 and that equation was simulated to produce forecasts of the employment ratio. Finally, these estimates were transformed into forecasts of the unemployment rate. These forecasts are shown in Table 2.

Over the eight-quarter period, actual per capita GNP growth averaged 5.2 percent. Simulation of the model predicted a decline in the unemployment rate of 2 percentage points. In fact, the unemployment rate declined by more than this: by 3.4 percentage points. The underprediction of the improvement in the employment ratio implies corresponding overpredicitons of the other components of real output growth. Examination of unrestricted simulations of the productivity and participation rate equations (that is, allowing the employment rate to vary rather than holding it constant) indicates that both female participation and labor productivity increased less rapidly over this period than historical relations would have pre-

Chart 4
Growth Rate of Per Capita Real GNP

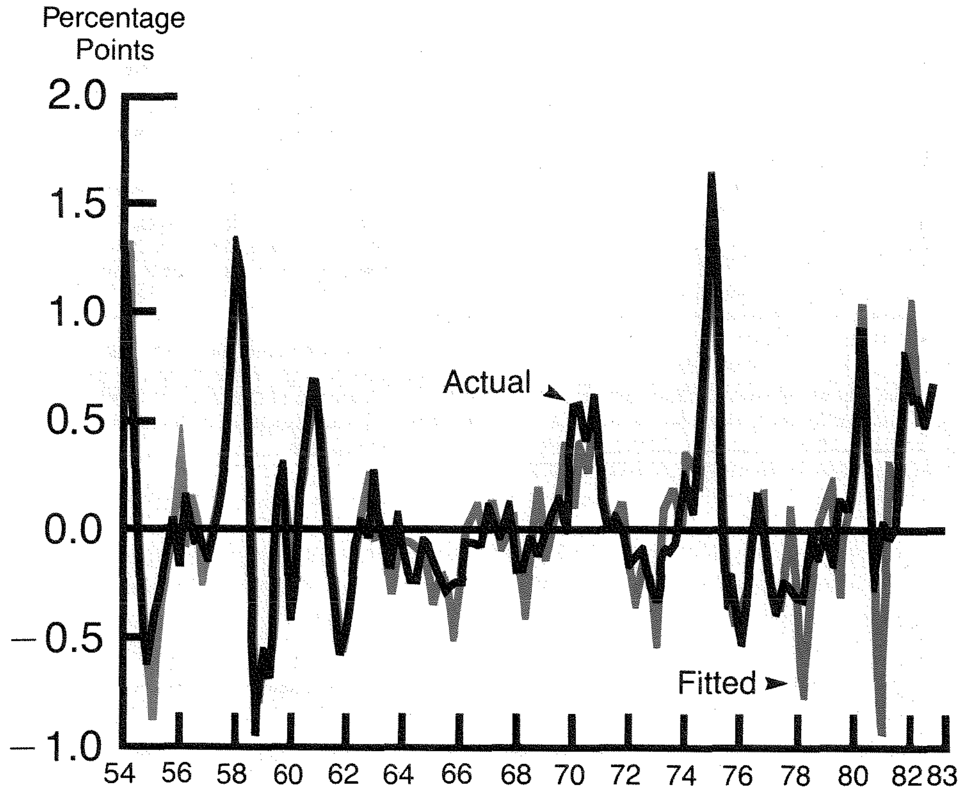


dicted. Thus, although the strong economic expansion did produce more rapid growth in productivity, participation and employment, the gain in productivity and participation was smaller than usual and hence, given the GNP growth that actually occurred, the gain in employment and the corresponding decline in the unemployment rate were larger. This outcome is somewhat ironic in view of earlier expectations that changes in tax policy would lead to *faster* productivity and labor supply growth.

However, Table 2 indicates that most of the prediction error occurred in 1983 when the unemployment rate fell much more rapidly than the model would have predicted. The error in 1984 was significantly smaller: from 1983(Q4) to 1984(Q4) the model predicted a decline in the unemployment rate of 1.1 percentage points compared to the actual decline of 1.3 percentage points. In view of this result, the model has been used to make projections of the unemployment rate over the four quarters of 1985.

To do so, the model was re-estimated through the fourth quarter of 1984. The estimated coefficients of the Okun's Law equation were essentially unchanged although the computed values of the required per capita GNP growth rate over 1983–84 were slightly lower than those forecasted on the basis of pre-1983 data. In making the forecasts for 1985, the required per capita GNP growth rate was assumed to remain constant at its 1984(Q4) level, namely two percent per annum. Real GNP was assumed to grow by four percent over the four quarters of 1985. Given the Census Bureau estimate that the adult population will rise 1.1 percent, this real growth assumption implies that per capita GNP will increase by 2.9 per-

Chart 5
Change in the Unemployment Rate
Actual vs. Fitted Values



cent. On the basis of these assumptions, simulation of the model indicated that the unemployment rate would decline modestly from its level of 7.2 percent in 1984(Q4) to 6.8 percent in the fourth quarter of this year.

Most economic forecasters outside the Administration expect real GNP growth in 1985 to be less than the four percent rate assumed in making this forecast. Most forecasts cluster around 3½ percent growth. Thus, one possible conclusion from these estimates would be that it is unlikely that much further progress will be made toward lowering the nation's unemployment rate this year. An alternative conclusion would be that a somewhat more rapid rate of real growth would not bring the economy significantly closer to a level of the unemployment rate at which the inflation rate would be likely to rise. This appears to be the Administration's position as it has suggested as a target the four percent growth rate assumed above. The estimates developed in this paper suggest that even a four percent growth rate would produce only a relatively modest decline in the unemployment rate and hence would not add significantly to the risks of inflation.

FOOTNOTES

1. Brian Motley, "How Soon will the U.S. Reach Full Employment? An Assessment Based on Okun's Law" *Economic Review,* Federal Reserve Bank of San Francisco, Number 3, Summer 1984.

2. For the purposes of this paper, the phrase "required growth rate" is more descriptive than "potential growth rate." The latter describes the rate at which the *supply* of output *could grow* while the former is that at which *demand needs to grow* to hold the unemployment rate constant.

3. Throughout this paper the phrase "adult population" refers to the civilian non-institutional population.

4. Output per worker may, in turn, be decomposed into output per hour and hours per worker. For simplicity, this decomposition is not made in this paper.

5. Representing the unemployment rate by u and the employment ratio by e, it can be shown that dln e is approximately equal to $-du$. This means that if the employment ratio increases at an annual rate of one percent, the unemployment rate declines by one percentage point per year.

6. Motley, *op. cit.* and Douglas G. Woodham, "The Changing Relationship between Unemployment and Real GNP in the United States," Research Paper No. 8407, Federal Reserve Bank of New York, September 1984.

7. Rose McElhattan, "Is the Economy Overheating?" unpublished paper, Federal Reserve Bank of San Francisco, March 1984; George L. Perry, "Potential Output and Productivity," *Brookings Papers on Economic Activity,* 1, 1977; Charles S. Morris, "The Productivity 'Slowdown': A Sectoral Analysis," *Economic Review,* Federal Reserve Bank of Kansas City, April 1984.

8. In each of the studies cited in the preceding footnote, the influence of the business cycle on labor force participation and productivity is represented by changes in employment or unemployment.

9. The equations also include the *change* in the employment rate. In the simulations this term was set to zero after 1953(Q1).

10. When both the current and lagged values of the required growth rate are included in the estimated equation, none of their coefficients is individually significant, but their sum is very close to the coefficient on the current value when it alone is included.

11. See Motley, *op. cit.,* and Woodham, *op. cit.*

12. Woodham's results, for example, imply that over the 1974–1983 period it would have required a 2.3 percentage point increase in the GNP growth rate to lower the unemployment rate by one point. See Woodham, *op. cit.,* Table 4.

13. The dependent variable in the estimated equation is the quarterly change in the logarithm of the employment ratio. For purposes of Chart 5, the fitted values have been transformed into quarterly percentage point changes in the unemployment rate.